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**Takahashi**

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(54) **SEMICONDUCTOR DEVICE**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,298,769 A	3/1994	Omura et al.
7,319,257 B2	1/2008	Yamaguchi et al.
8,550,968 B2	10/2013	Sugimura et al.
2010/0039844 A1	2/2010	Arai et al.
2014/0339600 A1	11/2014	Yoshikawa

OTHER PUBLICATIONS

Taiwanese Office Action dated Sep. 2, 2016, filed in Taiwan  
counterpart Patent Application No. 105107365, 6 pages (with  
English translation).

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**ABSTRACT**

A semiconductor device includes a second region of a second conductivity type above a first region of a first conductivity type. A gate electrode has a portion surrounded by the second region via a gate insulating layer. A first electrode, which is separated from the gate electrode, has a portion surrounded by the second region via a first insulating layer. A third region of a second conductivity type is between the first insulating layer and the gate insulating layer. The third region contacts the first insulating layer and has a second conductivity type carrier concentration higher than the second region. A fourth region has a portion aligned with the third region along a first direction. A fifth region of the second conductivity type contacts the gate insulating layer and is aligned with the first portion along a second direction perpendicular to the first direction.

**18 Claims, 5 Drawing Sheets**

